C/ORNL94-0256

ornl

OAK RIDGE NATIONAL LABORATORY

LOCKHEED MARTIN

CRADA Final Report
for CRADA Number ORNL94-0256

A Low-Waste Electrospray Method for Applying Chemicals and Finishing Agents to Textiles

X. (Shaw) Zhang
(Principal Investigator)
Oak Ridge National Laboratory

D. A. Alexander
(Principal Investigator)
AMTEX Partnership TReC Project

Prepared by the
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
managed by
Lockheed Martin Energy Research Corp.
for the
U.S. Department of Energy
under contract DE-AC-05-96OR22464

This work was supported through a CRADA with the AMTEX Partnership TReC Project, Spartanburg, South Carolina, sponsored by the Laboratory Technology Research Program Office, Office of Energy Research, U.S. Department of Energy, under contract DE-AC05-96OR22464 with Oak Ridge National Laboratory, managed by Lockheed Martin Energy Research Corporation.

MANAGED AND OPERATED BY
LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL-27 (3-96)

A Low-Waste Electrospray Method for Applying Chemicals and Finishing Agents to Textiles

Final Report for CRADA ORNL94-0256

X. (Shaw) Zhang
Oak Ridge National Laboratory
Chemical Technology Division

Abstract

This electrospray technology works by applying the desired chemicals onto a substrate as electrically generated, charged sprays. By imposing a potential difference between the application nozzle and the target, it is possible to precisely direct and control the spray. This electrospray method of application gives a small droplet size and a relatively uniform size distribution, with the added advantage of an easily controllable spray angle. It potentially offers substantial improvement over traditional methods in the area of application uniformity, resulting in improved product quality. Additionally, since the chemicals are electrically directed straight onto the fiber with a minimum of overspray, the electrospray method holds promise in the area of waste reduction, resulting in lowered production cost.

Statement of the Objectives

The objective of this project was to investigate the feasibility of improved application of chemicals and finishing agents to fabrics and yarns using electrospraying techniques. The collaborative work was to involve lab-scale studies primarily at ORNL, followed by testing with working prototypes at industrial pilot sites.

Technical Discussion of Work Performed

Work performed in fiscal year 1995 concentrated on electrostatic spraying of chemicals and finishing agents onto fabrics, and that in fiscal year 1996 concentrated on the electrohydrodynamic stable cone-jet spraying of droplets directed onto thread.

Multi-nozzle units for electrospraying chemicals and finishing agents onto fabrics were constructed and tested for different operating conditions. Based on the studies of electrostatic and hydrodynamic interactions among the charged liquid jets and sprayed droplets, the configuration of the system (including distances between nozzles, the nozzle and its sleeve, and electrodes) was adjusted for optimizing the spray quality (droplet size, spray angle, uniformity, and fabric wet pickup). The spray uniformity on fabrics was measured for solutions of industrial interest by digital scanning analysis and estimated on-line by simple measurements of wet pick-up at different positions across the width of fabrics. Both measurements showed relatively uniform coverage of the finishing materials on fabrics. In addition, the sprayed droplet size, size distribution, and velocity were measured by a phase-Doppler anemometer, which allows accurate characterization of the spray quality and correlation of the operating parameters for optimal operations.

A lab-scale electrospray unit with a single nozzle for spraying onto yarns was also developed and constructed. Experiments with different charging configurations were conducted. It was determined that a configuration in which the nozzle is grounded and the backplate is charged is the best suited for electrospraying onto yarn, as it readily produces a stable cone-jet spray of fine droplets (drop radius < 20 micrometers). This small drop size may result in a significant improvement over traditional liquid application methods. The grounded nozzle configuration is also advantageous in that any pump can be used without being insulated; the charged backplate is very easily insulated. Extensive and systematic experiments toward optimization of the quality and distribution of sprayed droplets of different liquids were carried out. Parameters investigated included liquid flow rate, viscosity, surface tension, and conductivity, as well as electric field strength and spray angle. Stable sprays were demonstrated with solutions over a 1-1500 cP viscosity range. Yarn path guides and a spin finish gear pump were provided by industry.

Unique contribution of ORNL to this project

ORNL was uniquely capable of contributing to this project since several years of research had been invested into the use of electric fields in oscillating, breaking and coalescing drops, and causing atomization. This lab has the electrospray equipment and instrumentation to obtain the necessary data, including a phase-Doppler anemometer for determining size distribution and velocities of aerosol droplets, and a high-speed image analyzer to study spray angles and the stability of liquid jets.

Benefits to DOE and ORNL

The work done on this CRADA was such that it improved our fundamental understanding of electrostatic spraying and deposition processes. The knowledge gained from this project can be adapted to phase-separation processes and advanced materials synthesis, thereby supporting ORNL competencies in separations, materials synthesis, characterization, and processing. A specific example is the knowledge generated in the single-nozzle studies, which supported efforts in an Office of Basic Energy Sciences project on interface stabilization and fine-droplet generation.

Inventions

No inventions were reported and pursued during the course of this work.

Plans for Future Collaboration

There were plans for another phase of experiments with pilot-scale processes, along with technique commercialization in FY1997; however, funding was not extended.

Conclusions

Although the project was not extended to pilot-scale testing and implementation, this work provided a significant benefit to the industrial partners by illustrating the feasibility and benefits of an electrospray method for applying chemicals and finishing agents to textiles. The electrospray technology offers an excellent opportunity to commercialize a process that could lead to an enhanced uniformity of chemical application, with a resulting improvement in the quality of industrial products. In addition, the possibility for a reduction in the amount of excess chemicals used in processing could potentially reduce operating costs.

INTERNAL DISTRIBUTION

1. D. W. DePaoli
2. A. J. Luffman
3. P. L. Gorman
4. R. T. Jubin
5. C. A. Valentine
6. X. Zhang

7–8. Laboratory Records

EXTERNAL DISTRIBUTION

9. D. A. Alexander, Director AMTEX Partnership TReC Project, 775 Spartan Blvd., Suite 203, Spartanburg, SC 29301.

10. P. S. Farber, Argonne National Laboratory, 9700 South Cass Ave., Argonne, IL 60439.